AD-756 387

S AND A MODULE FOR M514 'HORT INTRUSION FUZE

Kenneth W. Engelbrecht

General Time Corporation

Prepared for:

Harry Diamond Laboratories

September 1971

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HDL-008-1

S & A MODULE FOR M514 SHORT INTRUSION FUZE

Final Report

September 1971

by

Kenneth W. Engelbrecht

Prepared by:

WESTCLOX DIVISION
GENERAL TIME CORP.
315 East 5th St.
Peru, Illinois 61354

Under Contract Number

DAAG-39-71-C-0008

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UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* WESTCLOX DIVISION OF GENERAL TIME CORPORATION 315 East 5th Street Peru, Illinois 61354	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP NA

3. REPORT TITLE

S & A MODULE FOR M514 SHORT INTRUSION FUZE

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

FINAL REPORT SEPTEMBER 1971

5. AUTHOR(S) *(First name, middle initial, last name)*

KENNETH W. ENGELBRECHT

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
SEPTEMBER 1971	36	0

8a. CONTRACT OR GRANT NO. DAAG39-71-C-0008 b. PROJECT NO. c. AMCMS CODE: 4810.16.4734 d. H.D.L. PROJECT: 72742	9a. ORIGINATOR'S REPORT NUMBER(S) HDL-008-1 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Ammunition Procurement Supply Agency Joliet, Illinois 60436	U.S. ARMY MATERIAL COMMAND HARRY DIAMOND LABORATORIES WASHINGTON,D.C. 20438

13. ABSTRACT

THE WORK DONE TO DEVELOP DESIGN REFINEMENTS, FABRICATE, AND TEST 2000 S & A MODULES IN FIVE SEPARATE LOTS FOR THE M514 SHORT INTRUSION ARTILLERY PROXIMITY FUZE IS SUMMARIZED.

DD FORM 1 NOV 65 1473

Ia

UNCLASSIFIED

Security Classification

Security Classification UNCLASSIFIED

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
SAFETY & ARMING DEVICES	8	3				
ARTILLERY FUZES	8	3				
ESCAPEMENTS	8	3				

Ib

Security Classification

AMCMS Code: 4810.16.4734-1
HDL Proj: 72742

HDL-008-1

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1.0 GENERAL REQUIREMENTS

This contract required that Westclox fabricate a total of two-thousand (2,000) S & A Devices in five (5) lots, grouped as follows:

Lot No. 1	100 units
Lot No. 2	300 units
Lot No. 3	400 units
Lot No. 4	400 units
Lot No. 5	800 units

In addition to hardware fabrication and test, the contract called for the development of design refinements in the areas of the spin locks and springs, setback sensor, rotor detent, escapement, and diecast spacer. Work under this contract was accomplished during the period from August 1970 to August 1971.

The configuration of Lots No. 1 and No. 2 were of an interim design, bearing great similarity to the existing M564/565 D.A.M.A.A.M. - (Delay Arming Mechanism, Automated Assembly Module).

The configuration of Lots No. 3, 4, and 5 departed from the D.A.M.A.A.M. design, embodying additional areas of design refinement and improvement as proposed by Harry Diamond Laboratories, Westclox, or both. Greater detail regarding these variations will be provided in succeeding paragraphs.

2.0 LOT NO. 1 & LOT NO. 2

2.1 Design - In the interest of abiding by a very tight schedule, these first two lots were, in large part, identical to the existing D.A.M.A.A.M. S & A Device. Alterations to the D.A.M.A.A.M. parts, as well as any new parts, will be indicated below.

2.1.1 Bottom Plate - The periphery material at Hole #20, was clipped out to permit manipulation of the negator spring setback lock during test procedures.

2.1.2 Spacer - A ramp, along with appropriate recesses and reliefs, was milled in the spacer to accommodate the negator setback lock. This feature was located in accordance with Harry Diamond Laboratories drawings, but was re-oriented to improve clearances in the armed condition, and to give better results in the rework of the existing D.A.M.A.A.M. spacer.

2.1.3 Setback Lock - This was a new part of Harry Diamond Laboratories design. It was basically a coiled negator spring manufactured by the Hunter Spring Company. (See Figure 1) It was designed to give 40 foot drop safety and had a bias level specification of 800 - to - 1200 g's.

2.1.4 Detonator Sleeve Assembly - This is a new part of Harry Diamond Laboratories design. (Reference Figure 12) Its function is to provide an independent impact backup system to initiate the explosive train on ground impact. This subassembly consists of a M55 Stab Detonator and a RDX output charge in a steel sleeve. It is arranged to slide forward out of the rotor against a piston ring friction bias system after the rotor has armed.

2.1.5 Rotor Assembly - This assembly was made up from standard D.A.M.A.A.M. parts which were modified in order to accommodate the detonator sleeve assembly and setback lock. Material was removed from No. 1, No. 2, and No. 3 laminae around the outer periphery in the area of the detonator sleeve hole. The outside dimension here was reduced to .153 inches radius to compensate the position of the center of gravity of the rotor assembly for the heavier detonator. (See Figure 2)

2.1.6 Top Plate - The top plate was made from the D.A.M.A.A.M. plate. The small clip-out in the area of the setback lock was deleted. The center hole was enlarged and elongated to provide for positive passage of the detonator sleeve assembly on impact.

2.2 Fabrication & Assembly - As test units were assembled, it was immediately apparent that certain areas were not acceptable, and would require modification in order to correct the very erratic performance of the device. Arming time was quite unpredictable. Turns-to-arm varied from thirty (30) up to fifty (50), and occasionally even higher. Too often, the mechanism failed to arm at all. The following corrective actions were taken with the intent of increasing reliability.

2.2.1 Escapement - It had been known that the D.A.M.A.A.M. escapement design was of such configuration as to be very critical. There existed the tendency for the pallet pins to hang up on the escapement teeth, because the lift angle is unusually steep (12 teeth with an included angle of 55°). It was determined that the finish on the pallet pins did not meet Westclox standards. Since the pins could not be tumbled in the pallet assembly, it was necessary to hand-polish them on a power buffing wheel. A good finish was achieved. The impact surfaces of the escape wheel teeth were not as smooth as generally required for this type of mechanism. These surfaces could not be tumbled with the wheel and pinion assembled; therefore, these surfaces were also hand-polished on a power buffing wheel. Good results were obtained.

2.2.2 Rotor Assembly - The rotor gear, around the detonator, was milled down to .153 inches radius (See Figure 2). This coincides with the radius of the 1st, 2nd, and 3rd laminae. Removal of this material serves to move the center of gravity appreciably in a direction such that the torque output is increased at the beginning of the arming cycle. The leading corner of the 3rd lamina was milled off to give a ramp effect to prevent the intermittent hanging-up of the rotor on the rotor lock. (See Figure 1)

2.2.3 Setback Lock (Negator Spring) - A tendency for the setback lock to hang up on the rotor during the arming sequence was also experienced. It was necessary to go in with a tool (modified screwdriver), after assembly, and put a 90° downward bend in the setback lock at its point of emergence from between the top plate and the spacer. This apparently increased the clearance sufficiently to correct the interference conditions.

During the setback tests, the length of spring to be clipped from the negator coil, was recorded. Material length, as received, was 3.25 inches. Based on ten (10) trials, it was determined that the removal of 0.75 inches of material would give consistent arming at 1200 g's; however, this length produced very inconsistent results in the 800 g "no-arm" test. In the interest of keeping the program moving, Harry Diamond Laboratories suggested that the spring be designed for reliable arming at 1200g's, and sacrifice, temporarily, 100% reliability of no-arming at 800g's; this condition, of course, to be corrected at a later date, but before completion of the program.

2.2.4 Top Plate - Some difficulty was experienced in clamping the setback negator spring setback lock between the top plate and the spacer. It was determined, that a small coined ring in the lower surface of the top plate, and centered over the ledge in the spacer, would result in raising the surface of the plate so that clamping of the setback lock would be improved. The center hole was elongated additionally in the "plus Y direction to improve accommodation of the detonator sleeve assembly in case the rotor assembly 'over-travelled' in the armed position.

2.3 Test Results - Lots #1 and #2 were tested for turns-to-arm, setback bias level, and sliding detonator bias level, but variable data was not recorded. All units met the specification limits.

3.0 LOT NO. 3 (400 Units)

3.1 Design - It was originally intended that these units should embody all the features of the final design, as discussed below. As the program progressed, however, it became apparent that additional refinements and improvements would be incorporated - as discussed in Sections 3.2, 4., and 5..

3.1.1 Bottom Plate - The outside diameter was enlarged to the full size of the S & A Device. A clipped-out area was added to permit manipulation of the negator spring setback lock. Two holes were added for anticipated use in the spin test carriers. Four holes were positioned to accept the cast stub pillars in the spacer for assembling. Material specified was 2024-T3 or T4 aluminum.

3.1.2 Spacer - This is a new die-cast part, and zinc is used in place of aluminum. Four stub pillars were cast into both the top and bottom surfaces for staking on the plates. This arrangement eliminated four (4) assembly screws and four tapped holes. Two (2) cast in place stub dowels in both the top and bottom surfaces replaced the two separate steel dowel pins used in the D.A.M.A.A.M. design.

3.1.2 (continued)

The two top dowel stubs would be hollow-milled for accuracy in size and position, relative to the bottom dowel stubs. The positions of these dowels were changed slightly from the D.A.M.A.A.M. design (see paragraph 3.1.4). Provision was made for the rotor detent (see paragraph 3.1.3). The spacer was so designed as to permit inclusion of a MK349 fuze type set-back pin and spring configuration with a minimum of alteration and without disturbing or infringing on existing features. It was intended that the set-back pin system would be taken into consideration as an alternative design in the event difficulties should appear regarding the negator spring set-back lock.

3.1.3 Rotor Detent (See Figure 3 & 4) - The existing D.A.M.A.A.M. rotor detent and spring have demonstrated shortcomings. At normal rates of spin, and after set-back has subsided, the detent rides the underside of the top plate as the rotor rotates into the armed position. This condition, of course, reduces the usable rotor torque. Also, at rates of spin above 8000 rpm, centrifugal force causes the retracted detent to bear against the side of the detent cavity in the rotor, and tends to make locking in the armed position unreliable. A considerable number of alternative designs were considered, some of which were submitted by Harry Diamond Laboratories and others by Westclox. It was finally agreed upon by both parties, to investigate and develop this one-piece detent design, since it would not consume rotor torque, would operate under all spin environments, and would eliminate the spring.

3.1.4 Spin Locks - These were standard D.A.M.A.A.M. parts, but were slightly repositioned relative to the rotor gear, to give parallelism between the lines connecting the spin lock c.g. and the pivot center of each of the two spin locks, when in the unarmed position. The reason for this change was to improve the safe condition under particular adverse handling environments; that is, it is theoretically possible to drop the D.A.M.A.A.M. device in such a manner that both spin locks would simultaneously tend to disengage from the rotor gear. The repositioning also improves the drive torque on thelower lock and gives a better balance on the torque for both locks. The new positions and revised cavity in the spacer also permitted use of a single spring design for both locks in place of the two different springs in the D.A.M.A.A.M. design.

3.1.5 Setback Lock - It was not anticipated at this point in time, to depart from the proposed design. Harry Diamond Laboratories and Frankford Arsenal had done considerable calculation and testing on this device, and it is understood that some degree of success was achieved. It was assumed that, at most,minor adjustments, subsequent to Lot No. 1 and No. 2 testing would be necessary to satisfy the requirements of Lots No. 3, No. 4, and No. 5. In the event unexpected assembly problems are encountered, or should test results prove to be unacceptable, Westclox made provision for an alternative design as described in Paragraph 3.1.2 above. This alternative design was so arranged as to be capable of incorporation at minimum cost.

3.1.6 Setback Lock Stop - This was a new part added to the rotor to prevent the setback spring from coming out of its notch during a sideways impact. Testing on Lots #1 and #2 revealed that the spring would not reliably reset in the notch if it was knocked out. The incorporation of this separate part into the design, permitted delivery of the rotor gears and No. 3 lamina at a considerable earlier date than would otherwise have been possible, had it been necessary to blank these two parts with integral extensions to serve as the stop. The standard D.A.M.A.A.M. No. 3 lamina was to be milled to accept the stop and the assembly rivet would hold it in place. This arrangement would permit a return to the old configuration with a minimum effort, being only necessary to omit the milled slot in the No. 3 lamina. (See Figure 1)

3.1.7 Top Plate - Various holes were added for pillars, unarming probes, and spin lock access. Also, the center hole was elongated to provide positive access for the detonator sleeve assembly. Using an elongated hole, solves the access requirement and also gives maximum plate material between the rotor pivot hole and the center hole. Aluminum 2024T3 or T4 was selected for the plate material.

3.2 Fabrication and Assembly - During fabrication, assembly, and testing of initial Lot No. 3 units, some design refinements were found desirable, as follows.

3.2.1 Spacer - A considerable amount of rework has to be done on the castings before they could be used. This rework consisted of removing large amounts of flash, filing of mismatched surfaces, and the removal of tiny, but unacceptable 'lumps' or 'fins' in various critical surfaces. In addition, the .030 inch ledge, which supported the setback lock, was depressed approximately .004 inch below the top surface of the spacer. Had this surface been level, the coining described below in Paragraph 3.2.2, would very probably have been reduced, if not completely eliminated.

In view of the need for clamping the setback lock, and possibly unclamping for adjustment, it was determined that the stub pillar at the No. 3 position should be removed and replaced with a tapped hole. This permitted use of an assembly screw, which compared to the arrangement used in Lots No. 1 and No. 2.

3.2.2 Top Plate - A punched slot was added immediately over the point of emergence of the rotor lock from between the spacer and the top plate. The purpose of this slot was to provide better access for the tool used to apply a 90° post assembly downward bend in the rotor lock, and to provide visual access for inspection purposes. The small coined ring referred to in Paragraph 2.2.4, did not work as well on the aluminum plates as had been anticipated. The punched slot, described above, may have been at least partially responsible for the poor coining. At any rate, the plate was coined from the top, thus forming a .004 inch bump in the bottom surface of the plate in the area directly over the setback lock 'ledge' in the spacer. This gave an improved clamping condition for the setback lock.

3.2.3 Setback Lock - The setback locks, as received from Hunter Spring Company, were generally in good shape. The 'open' outer half coil was satisfactory. The O.D., width, and material thickness,were all within tolerance. A number of the parts, however, exhibited a loose coil at about the middle of the strip. The setback lock coils also exhibited the characteristics of not being capable of positive realignment after having been slightly telescoped. This characteristic is probably inherent, and should be considered undesirable.

Results of a post-assembly probing methodof bending the supporting end of the rotor lock, proved to be somewhat inconeistent and unreliable. Therefore, a pre-bent supporting end was incorporated. The formed end consisted of two 90° bends - one located approximately .050 inches from the end - the other approximately .031 inches in from the first. This distance gave a good fit over the spacer ledge. Even though temporary type holding fixtures and bending tools were used in forming the supporting end of the setback lock, a high degree of care and expertise on the part of the Westclox Model-Makers resulted in a very uniform 'hook'.

3.2.4 Rotor Detent - Samples,made from .032 inch thick strip brass, were taken from the blanking tool, which was fabricated by the Westclox Model Shop, and tested. Results were favorable from the beginning. Action at 1200 rpm under a strobe light, was observed. However, the camming and locking action was so fast as to be not readily detectable visually. Generally, the action appeared to be smooth and effortless, with reference to its effect on the motion of the rotor assembly. No difficulties were experienced when the device was tested at 2300 rpm..

3.2.5 Rotor Assembly - The rotor assembly was finally assembled per Paragraph 2.2.2, with the following exceptions. The trailing corner of the cut-out in the third lamina, immediately below the upper spin-lock notch, was milled back, similar to the leading edge of the third lamina. The reason for this ramp was to eliminate the tendency for the rotor lock to hang-up on the rotor during resetting. There was some tendency for the upper spin-lock to cam out when the rotor was manually rotated in the arming direction. Complete camming out, however, did not occur. Therefore,no corrective action was taken for Lot No. 3. It was agreed that ways to improve this condition for Lots No. 4 and No. 5 should be investigated.

3.3 Test Results - In summary, all 400 units met the 1200g go setback lock test, 1200 rpm no go spin test, 2300 rpm go spin test. Ten units passed jolt, 10 passed jumble, and 10 passed 40 foot drop. Twenty were tested after TV and another 20 after 7 foot drop. The impact system bias remained within the 10 to 30 g spec limits after these tests, but there were some arming failures. After TV, all 20 armed at 2300 rpm but then one failed to arm and one armed long in the 2700 rpm turns-to-arm test. Two of the Negator setback locks failed to arm at 1200 g. The worst failures resulted from the 7 foot drop test, where only 7 of 20 units passed all tests. Two failed to arm at 2300 rpm, 5 failed to arm at 2700 rpm, and 5 others armed long,and 4 setback locks failed to arm at 1200 g. Thirty units selected at random from the 70 environmentally conditioned units were checked for functioning of the impact backup system and explosive train. All 30 functioned on the 30 inch drop and gave dents in aluminum ranging from 0.06 to 0.09 inch deep. The turns-to-arm and dent depth data is summarized in Figure 5.

4.0 LOT NO. 4 (400 Units)

4.1 Design - The design of Lot No. 4 differed from Lot No. 3, as follows.

4.1.1 Rotor Detent - These parts were fabricated from .040 inch brass strip, instead of .032 inch thick in order to increase strength and reduce the free play between the spacer and the top plate.

4.1.2 Alternate Setback Pin Design - The desirability of fabricating some portion of Lot No. 4, which would incorporate an alternate setback lock design, was discussed with Harry Diamond Laboratories' representatives. It was subsequently agreed, that of the total of 400 units making up this lot, 350 units would incorporate the negator spring setback lock, and 50 units would incorporate the setback pin feature shown in Figures 6 and 7.

4.2 Fabrication - In order to accommodate the alternate setback pin feature into the 50 units, it was necessary to modify the existing castings (See Paragraph 3.1.2). In milling out material from the casting to the extent necessary, voids were encountered and it was found necessary to partially rework approximately 90 spacers to obtain 50 good, reworked parts. This problem was not expected to be present in the redesigned casting.

4.3 Test Results - The turns-to-arm data for the lot of 350 units with the negator setback lock, is shown in Figure 8. This figure also shows that the 50 pound load on the top plate does not significantly effect performance. The 100 units were run with no-load first so the 0.5 turn average decrease for the load data could be due to wear-in effects. Test results showing the effect of temperature on turns-to-arm of 50 different units at each temperature, are presented in Figure 9. The bias level performance of the negator setback lock and piston ring sliding detonator system are shown for 100 units each in Figure 10.

Units with the negator setback locks were tested, as follows - 5 jolt, 10 jumble, 5 TV procedure I, and 30 for detonator firing in test vehicles. All 20 environmental units passed the tests. The 30 dent depths from the firing test ranged from 0.064 to 0.106 inches.

The performance results for the 50 special units with the alternate setback pin are shown in Figure 11. In addition to the bias level tests, these 50 units were used to complete the Lot 4 environmental test requirements. Five were jolt tested; 15 went through TV; 10 through 40-foot drop and 20 through 7-foot drop. Before these tests, all 50 units met the impact system bias level requirements, all met the 1200 rpm no-arm and 2300 rpm arm requirement, and all armed within specification at 2700 rpm with an average of 32.1 turns-to-arm. All 5 passed the jolt test except that there was one 'no-test' because the test vehicle came apart. Of the 15 tested after TV, all were safe and met the turns-to-arm specification with an average of 32.8. The average bias on the setback lock increased by 50g and two units were 16 g over the specification upper bias limit. Two units failed to meet the 30g go impact system bias specification. Of the 20 seven foot drop units, all were safe and the average turns-to-arm was 33.6 after the test. Two units dropped 45° nose down would not arm because of distorted parts and a 3rd had a loose top plate. (cont.)

4.3 (continued)

All four units dropped base down, had the setback pin armed. So did 2 of 4 at 45° base down and 1 of 4 horizontal. The average setback pin bias level remained about the same as before the test. All 10 forty-foot drop units were safe and passed the test but there were some bent and distorted parts and the 2 base down units had armed setback pins.

5.0 LOT NO. 5 (800 Units)

5.1 Design - The design of Lot No. 5 reflected a substantial departure from the designs of previous lots. These changes consisted of both Westclox and Harry Diamond Laboratories originated configurations, and appear in Lot No. 5 drawing package dated February 1, 1971, submitted to Westclox by Harry Diamond Laboratories. (See Figure 12) A general reference to these changes, is given below.

5.1.1 Setback Pin - The setback pin feature, discussed in Section 4.1.2, was incorporated in lieu of the negator setback lock. This mechanism consists of a notched pin, a U-shaped spring, and a retainer-pin, all so arranged that the lower spin lock is obstructed from disengaging the rotor gear notch until a gun-initiated setback environment is experienced. A specification of 900g's no-arm and 1200g's arm was established on the basis of the 50 sample test from Lot No. 4. (Reference Figure 11).

5.1.2 Plates - Nominal thickness of the top and bottom plates was changed from .042 inches to .050 inches. This increase in thickness gives an increase in bearing area for the rotor shaft pivots. It should be noted, that this change resulted in an increase of .016 inches in the overall thickness of the device. Some other features in these two parts were revised, such as locations and shapes of the rotor arming - unarming probe slot in the top plate, counterbores in place of countersinks for staking the stub pillars in both plates, and relocation of the assembly screw in the top plate. This screw was used on only the first one-hundred (100) units, and was then replaced with a staked pillar.

5.1.3 Escapement - As discussed in Section 2.2.1, it was known that the existing D.A.M.A.A.M. escapement design was inadequate and would require improvement. It was also found that, with special treatment of the parts involved, the D.A.M.A.A.M. configuration could be made to function. However, the results were still considered marginal. Various alternative configurations were devised, and tested on the spin fixture. A mean-arming time delay of approximately 34.5 turns-to-arm, with a tolerance of approximately ±15% (29 to 42 turns) was desired.

The final design is compared with the D.A.M.A.A.M. design in Figures 13 and 14. The values for linkage ratio shown in Figure 14, represent the torque reduction ratio between the escapewheel and pallet as a function of the depth of engagement between the pallet pin and escapewheel tooth. For example, when the exit pin on the D.A.M.A.A.M. escapement design is at a point 22 percent in from the tip of an escapewheel tooth, and the coefficient of

5.1.3 (continued)

friction is 0.2 (see point A), then the pallet is driven with only one-third of torque supplied at the escapewheel.

The escapewheel tooth included angle was increased from 55 degrees to 68 degrees; the wheel thickness was increased from .016 to .020; the pallet pin diameters were increased from .025 to .030 inches; the pallet pins are located unsymetrically with the entrance pin being at a greater distance from the pivot center than the exit pin; the pallet pins span 1.5 escapewheel teeth instead of 2.5 teeth; the pallet mass was decreased by 4 percent, while its inertia was increased by 30 percent; and the pallet is unbalanced to assist operation at the entrance pin.

5.1.4 Spin Lock - The spin lock profile was altered so as to give an improved relationship between the setback pin and the lower spin lock, and also to give an improved intersection of the upper spin lock with the safe assembly cavity (see Figure 1) when the rotor assembly is in any position other than the completely unarmed position.

5.1.5 Rotor Assembly - This assembly incorporated changes resulting from elimination of features included in the design of Lot No. 3 and 4. These included elimination of the setback lock stop, the routing in No. 3 lamina, the cam surfaces mentioned in paragraphs 2.2.2 and 3.2.5, and the large chamfer on the lower corner of the outside periphery of No. 3 lamina. These should all result in a cost reduction and should serve to move the c.g. of the rotor assembly to a more effective position. A revised profile for the

5.1.5 (continued)

hook which engages the upper spin lock, corrected the camming condition mentioned in paragraph 3.2.5. The thickness of lamina 1 and lamina 3 was reduced from 0.0946 to 0.0907 in order to more easily maintain the .376 maximum length of the assembly. The lower shoulder on the rotor shaft was tapered $0^{\circ} - 30' + 15''$ in order to reduce torque losses during the arming cycle. The rotor shaft pivots lengths were extended to equal the plate thickness and the chamfer on the pivots was eliminated in order to increase safety (retain engagement) in 40 foot drop tests.

5.1.6 Spacer - This part was considerably revised to accommodate the various changes described above. In particular, the ramp configuration and attendant notch were deleted, and provision was made to accept the set-back pin mechanism described in Paragraph 5.1.1 above.

5.2 Test Results - In additon to changing the design for Lot 5, the test specifications were also changed. The 2300 rpm arming test and the 2700 rpm turns-to-arm test were combined into a 2500 rpm turns-to-arm test. The specification limits were changed from 28 to 40 turns to 29 to 42 turns.

All 800 units were checked for setback lock operation, turns-to-arm, impact system bias, and non-arming speed. Turns-to-arm data for the lot is shown in Figure 15. All units met the other requirements. A sample of 273 units from the 800 were then subjected to various environmental tests. A summary of the tests is shown in Figure 16. All units met the appropriate MIL-STD safety criteria. Of the 200 units from TV,

5.2 (continued)

5-foot drop, and extreme temperature conditioning, 144 units tested for non-arm speed (1000 rpm) and 179 tested for impact system bias level (12 to 39 grams), met the specification requirements. Not all of the 200 units were tested because some had failed either the turns-to-arm test or the setback lock bias tests and were held for further examination. Only two of the 200 failed to arm at 2500 rpm after conditioning, but 21 others were out of spec. on turns-to-arm. Nineteen of the 23 bad units, were respun and all met the spec limits on this second run. Only 179 units were tested on the centrifuge for setback lock bias and 142 met the specification limits of 900 to 1200 g. Of the 37 out of spec, 13 met the 1200 g test on the second try. Of the other 24, 13 met a 1200 g static load test, 10 armed at a higher static load (the highest was 1730 g), and one armed at less than 900 g due to a bent spring. The firing test consists of checking the sliding detonator assembly for a stab sensitivity of 0.75 inch ounces. Problems with the firing test fixture delayed this test at first, but then it was discovered that the design of the sliding detonator assembly was causing problems. The cork cushion, used to take up stack tolerances in the assembly, was preventing proper energy transfer from the firing pin. H.D.L. refined the detonator assembly design to eliminate this problem, but the firing test had to be postponed to fall under a subsequent contract when detonators of the new design would be available.

6.0 Summary - Results indicate the end product to be free of major shortcomings. Performance has been good and generally speaking, all parts, assemblies, etc., are of a practical nature, and should present a minimum of difficulty in full production operations.

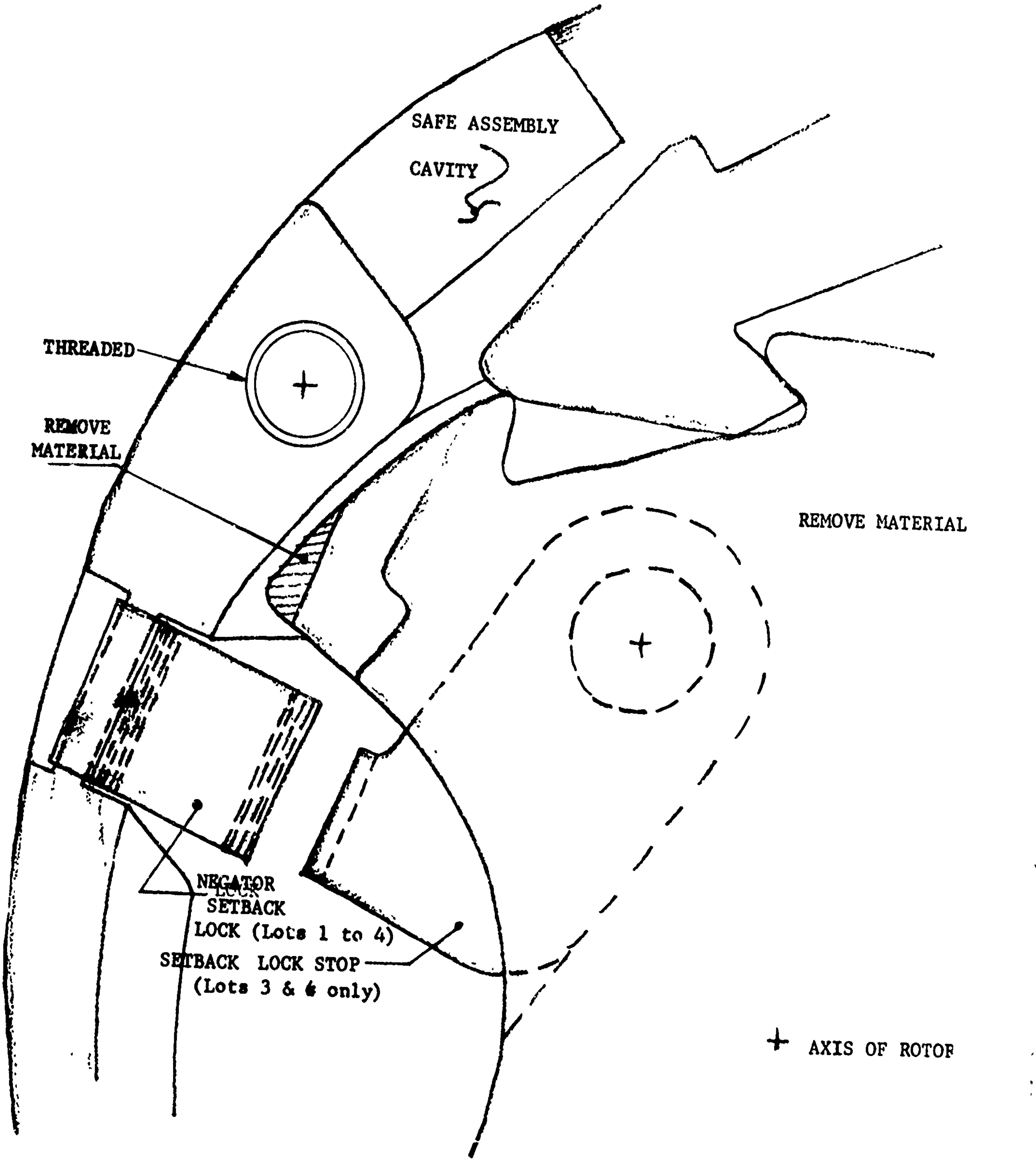

FIGURE 1 - SETBACK LOCK DETAIL - ROTOR IN SAFE POSITION

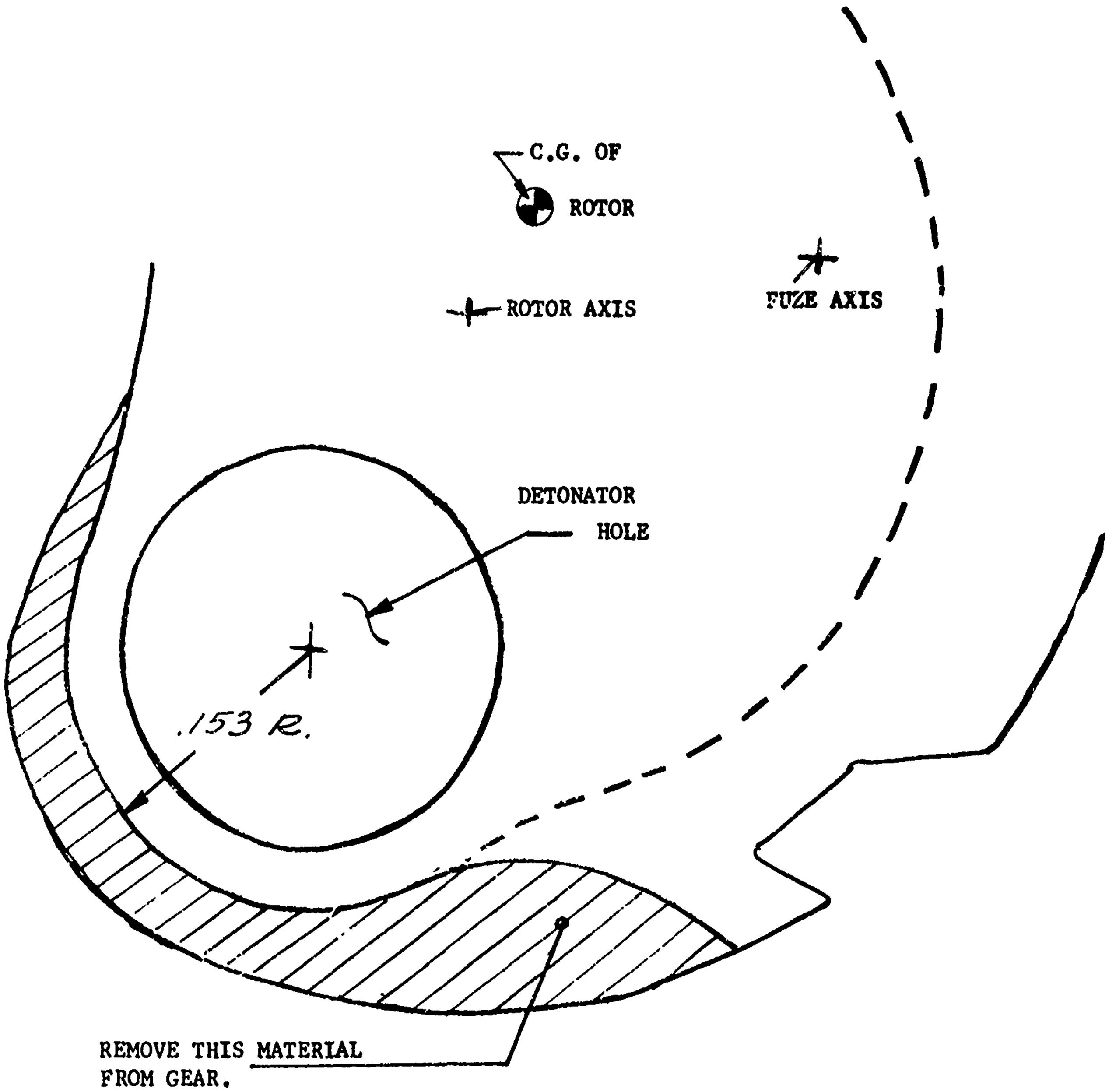

FIGURE 2 - ROTOR GEAR MODIFICATION DETAIL

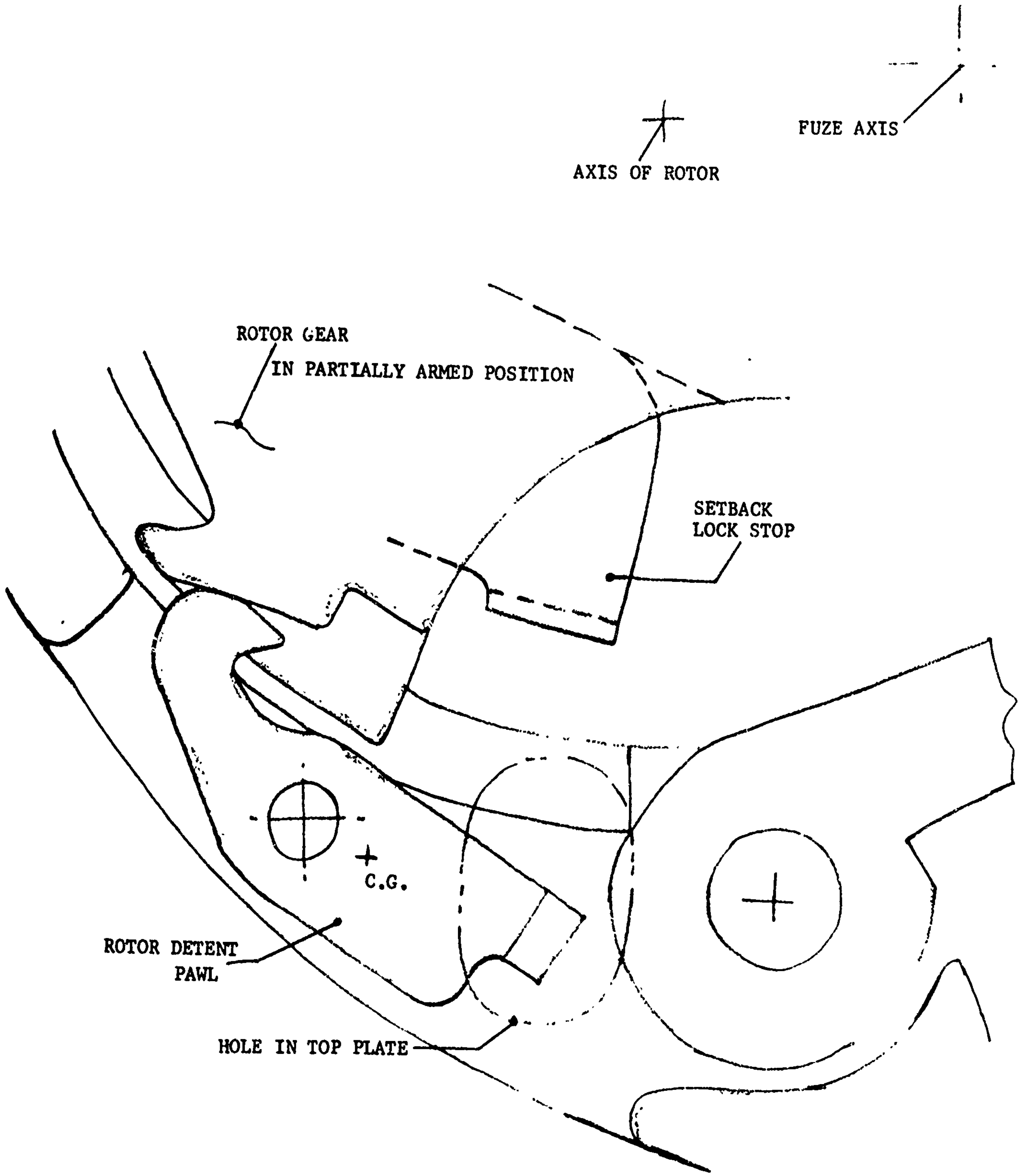

FIGURE 3 - ROTOR DETENT DETAIL - ROTOR PARTIALLY ARMED

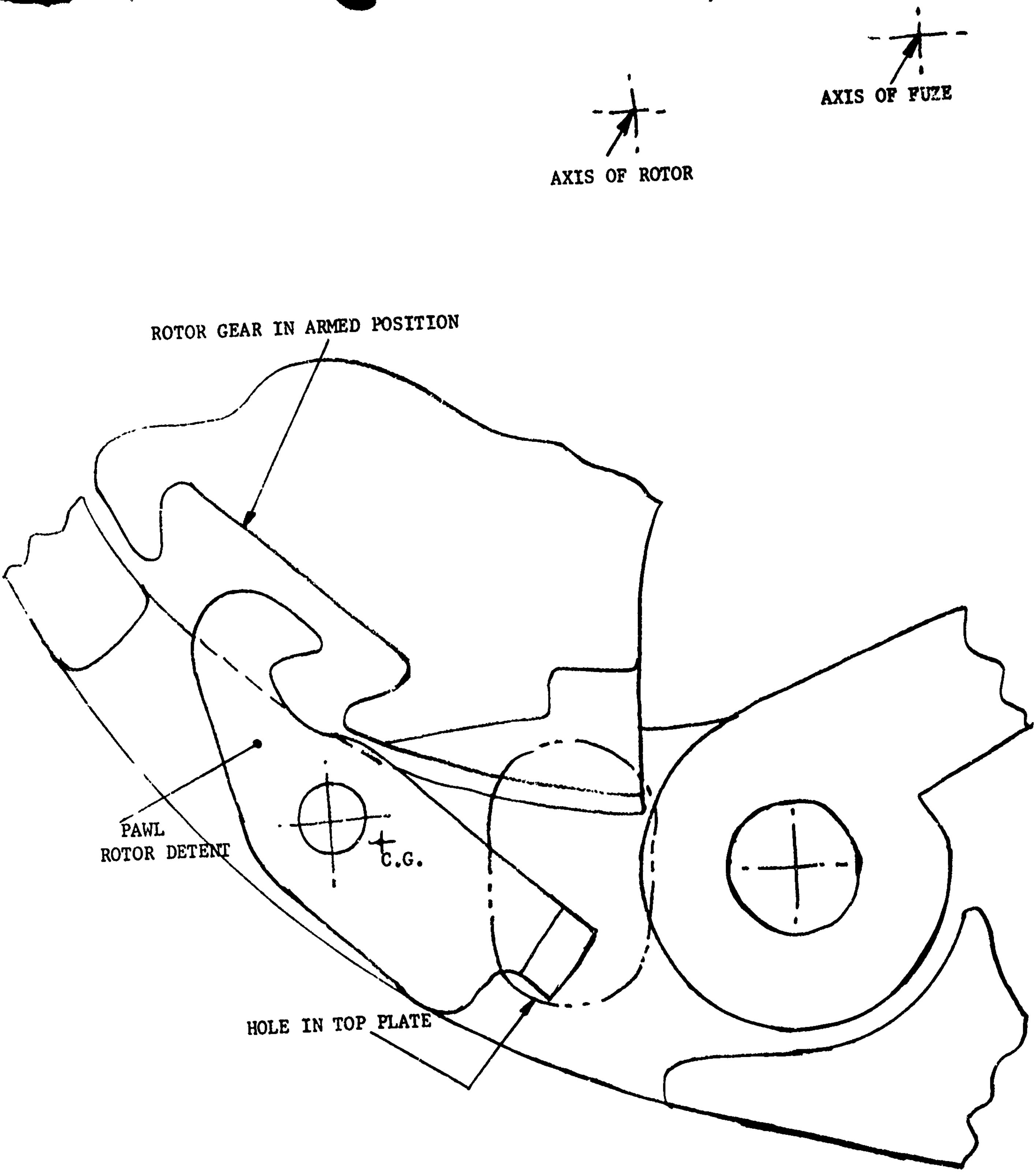

FIGURE 4 - ROTOR DETENT DETAIL - ROTOR FULLY ARMED

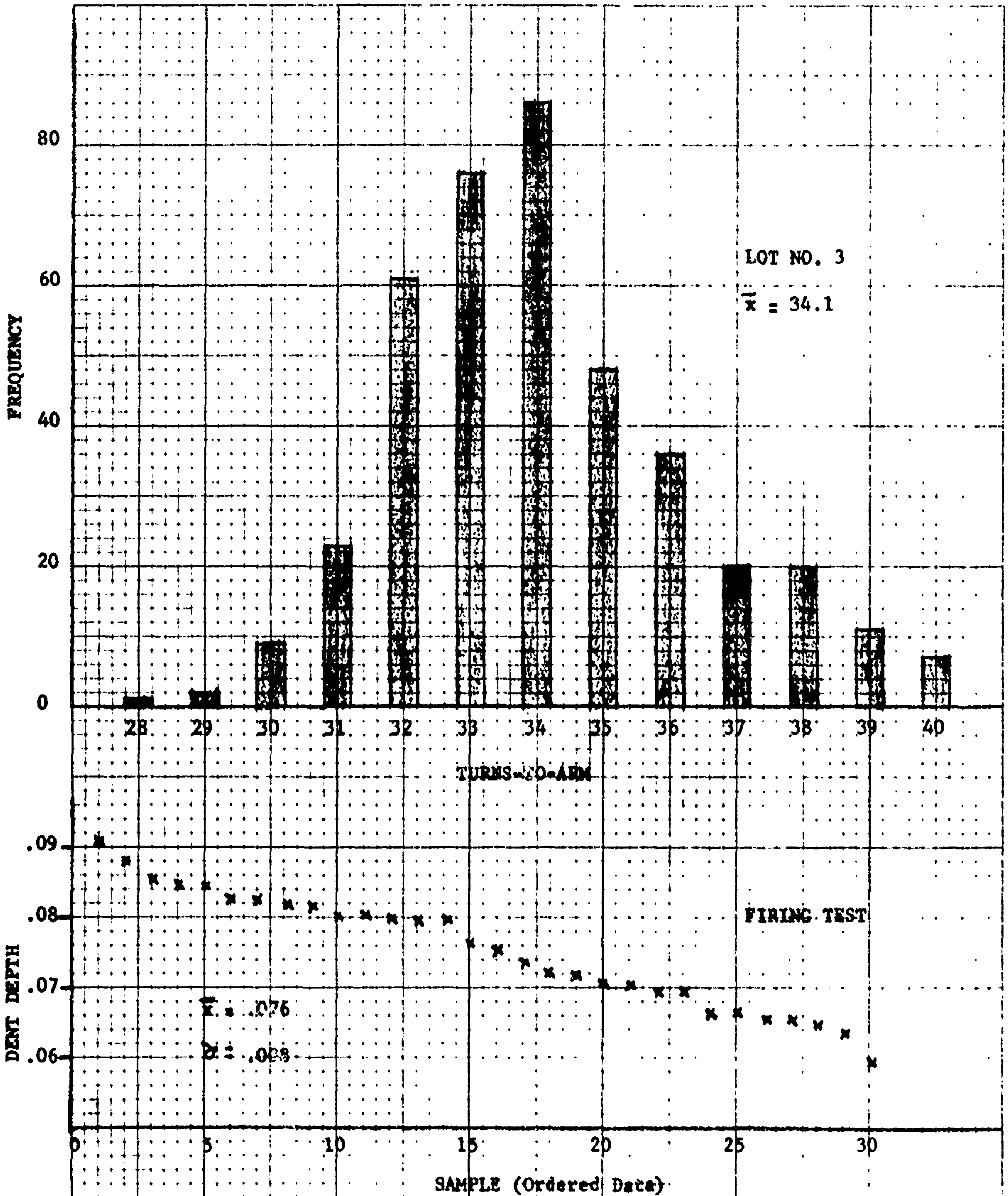

FIGURE 5 - TEST DATA FROM LOT NO. 3

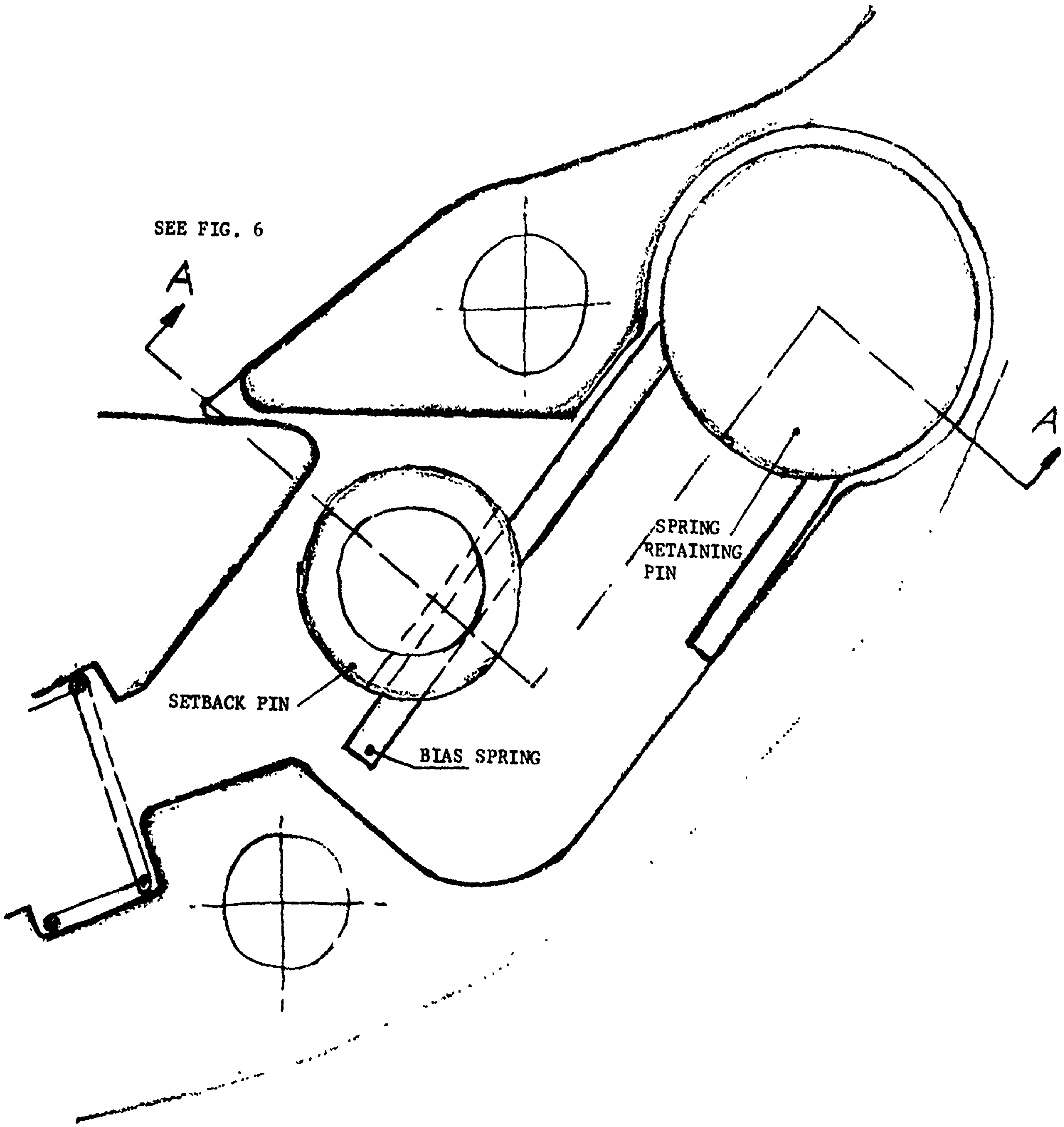

FIGURE 6 - ALTERNATE SETBACK PIN DESIGN - TOP VIEW

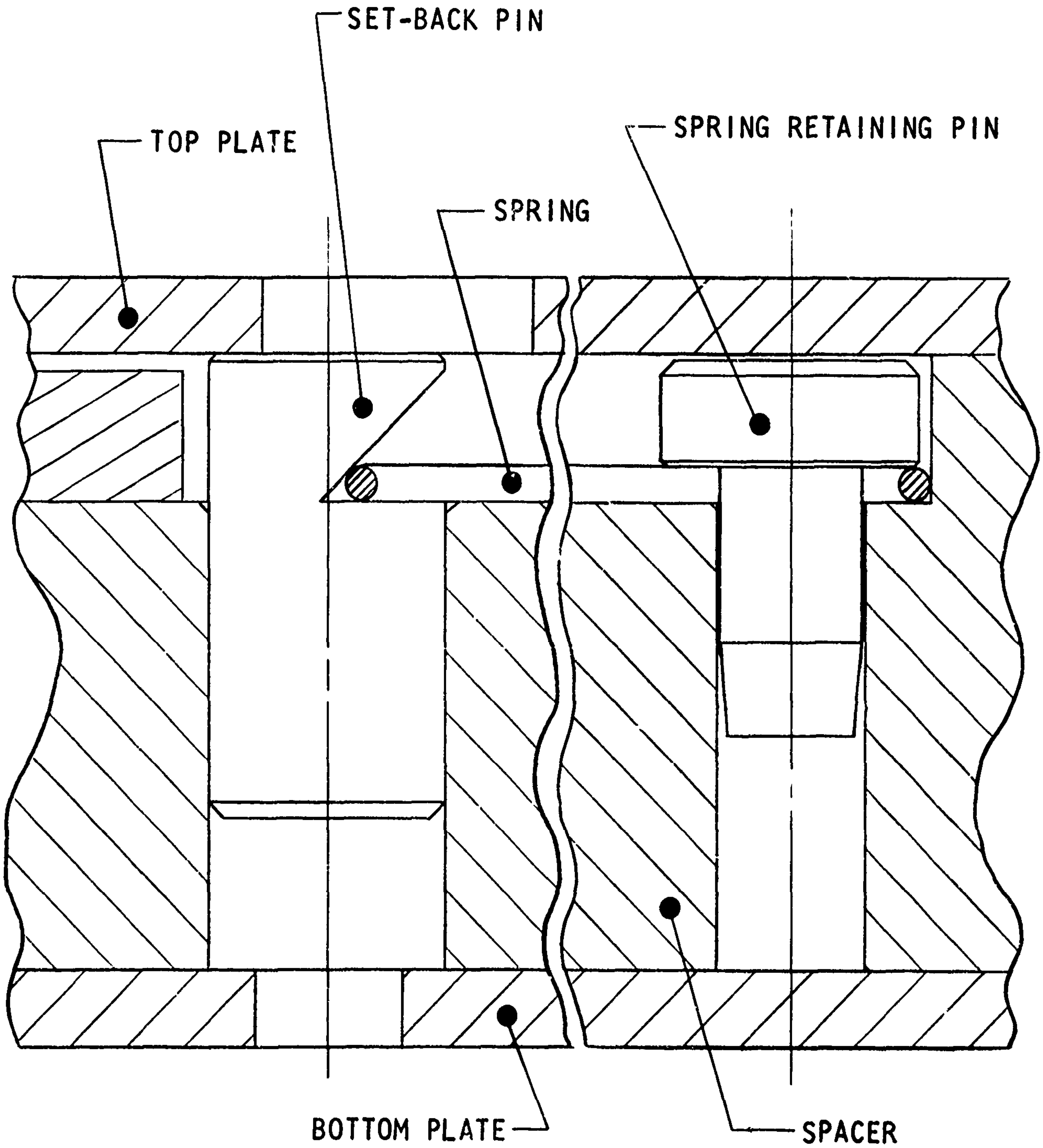

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FIGURE 7 - ALTERNATE SETBACK PIN DESIGN - SECTION VIEW

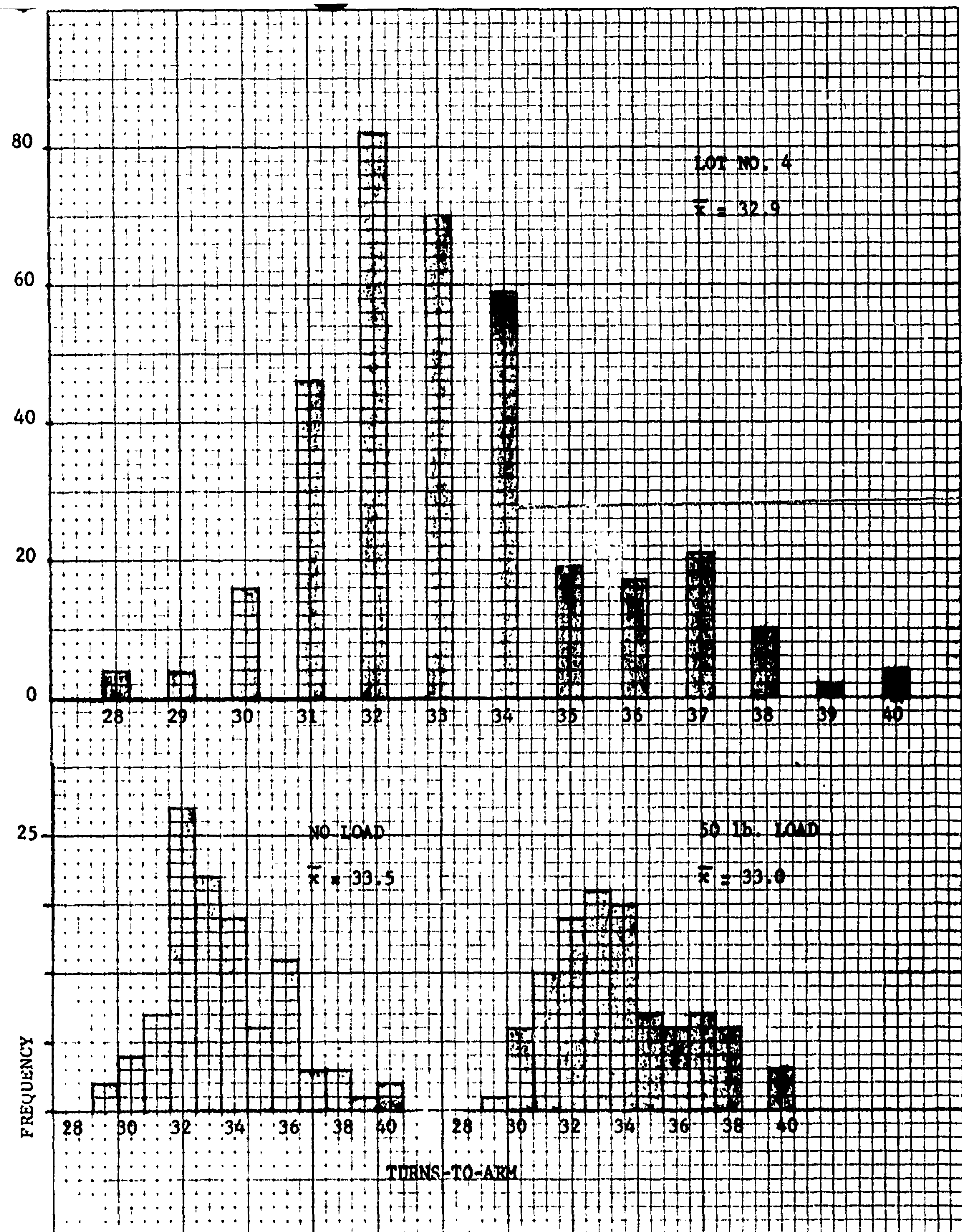


FIGURE 8 - TURNS-TO-ARM & LOAD TEST DATA FOR LOT NO. 4

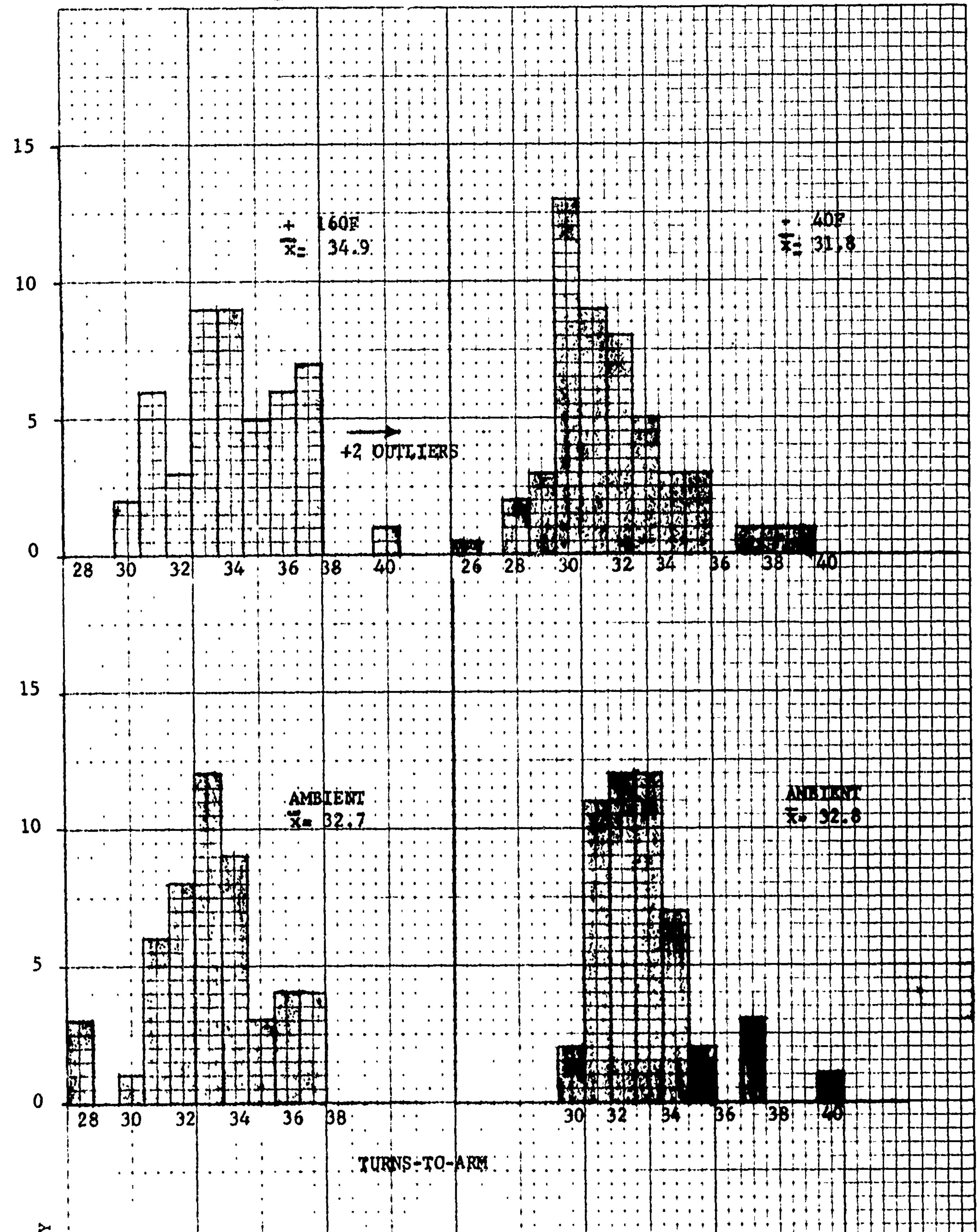


FIGURE 9 - TEMPERATURE TEST DATA ON 100 LOT 4 UNITS.

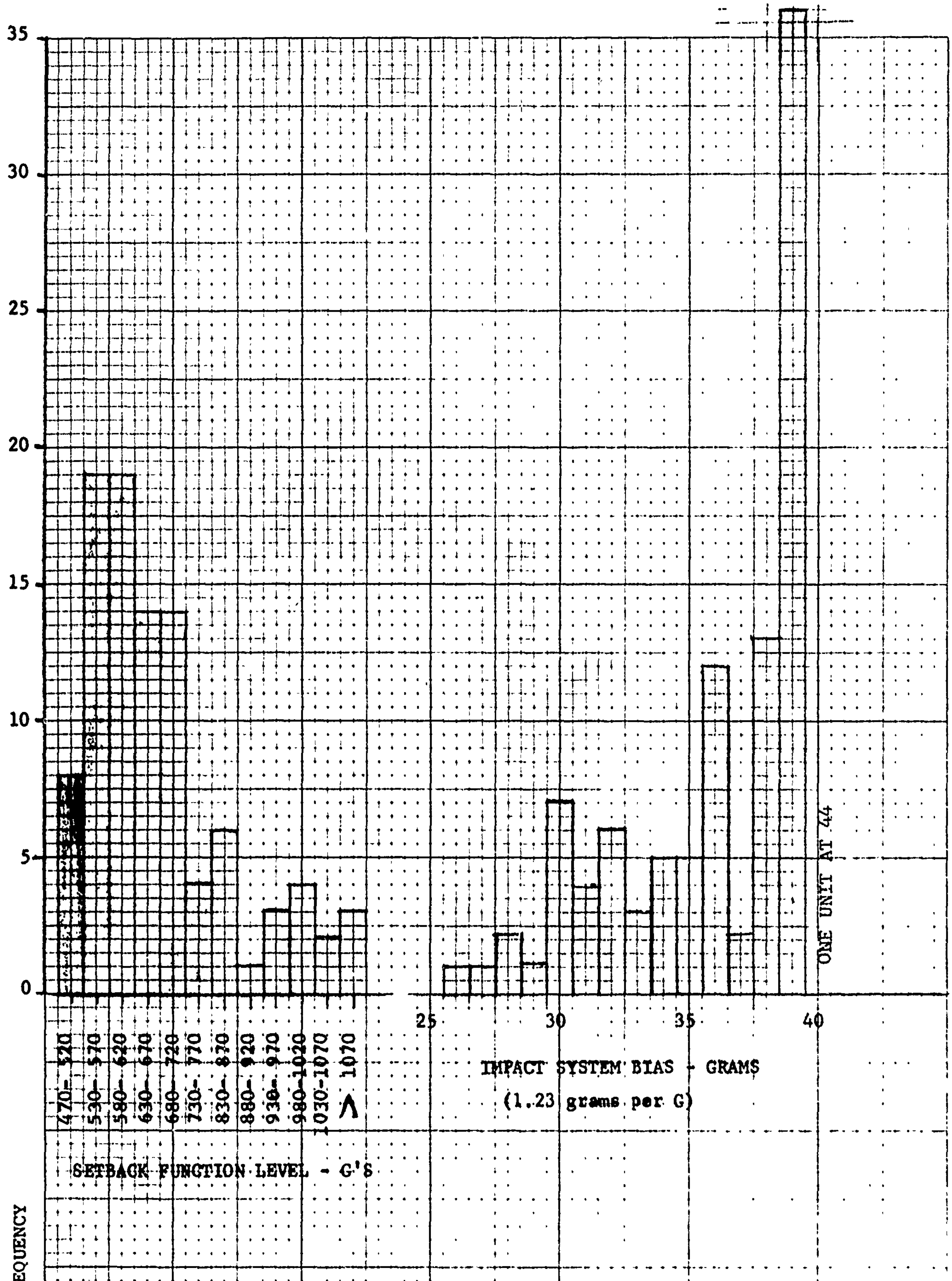


FIGURE 10 - PERFORMANCE OF SETBACK LOCK & IMPACT SYSTEM ON 100 LOT NO. 4 UNITS.

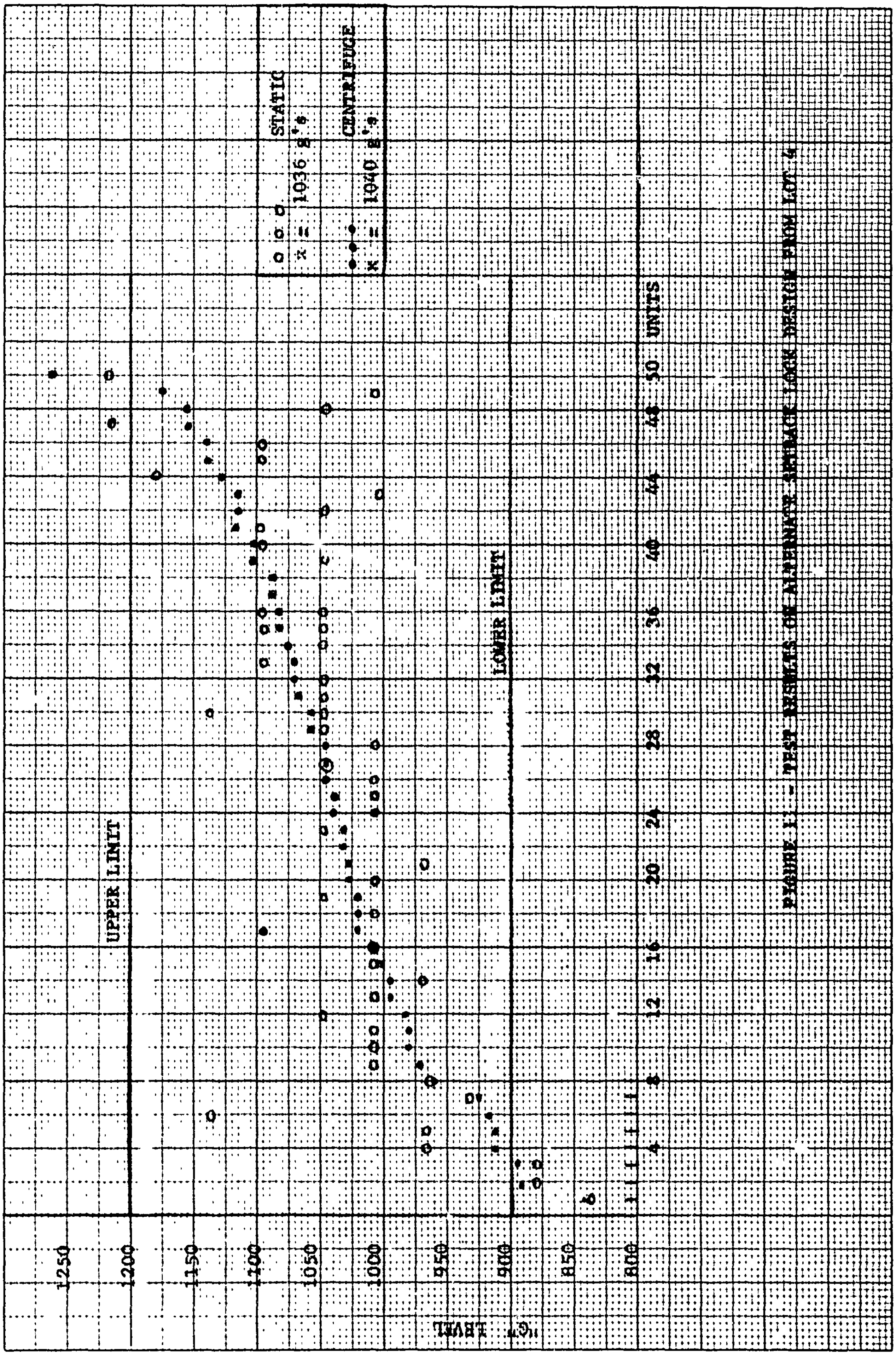
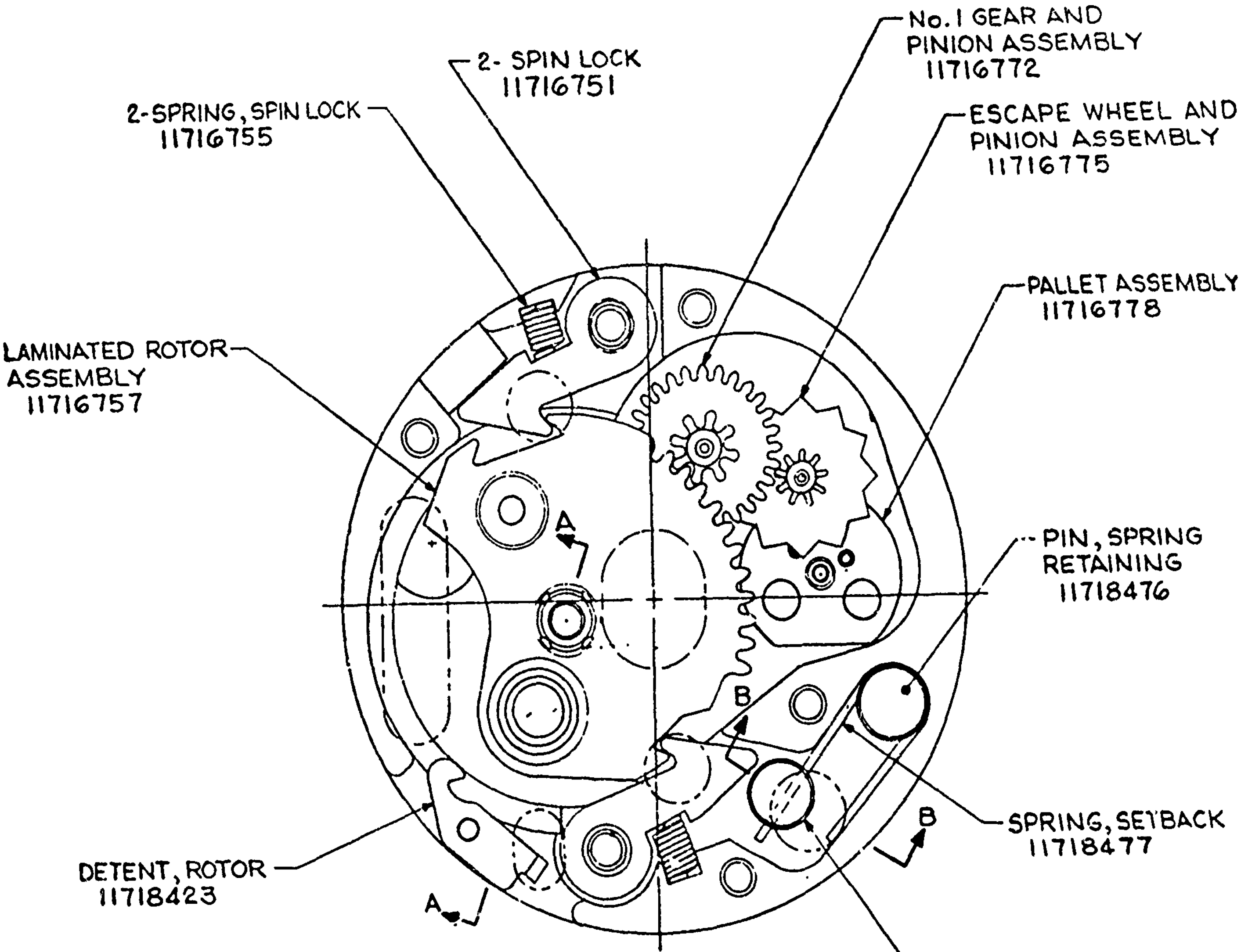


FIGURE 13 - TEST RESULTS ON ALTERNATE SETBACK LOCK DESIGN FROM LOT 4



VIEW SHOWN WITH TOP PLATE REMOVED
PHANTOM LINES SHOW ACCESS HOLES IN TOP PLATE

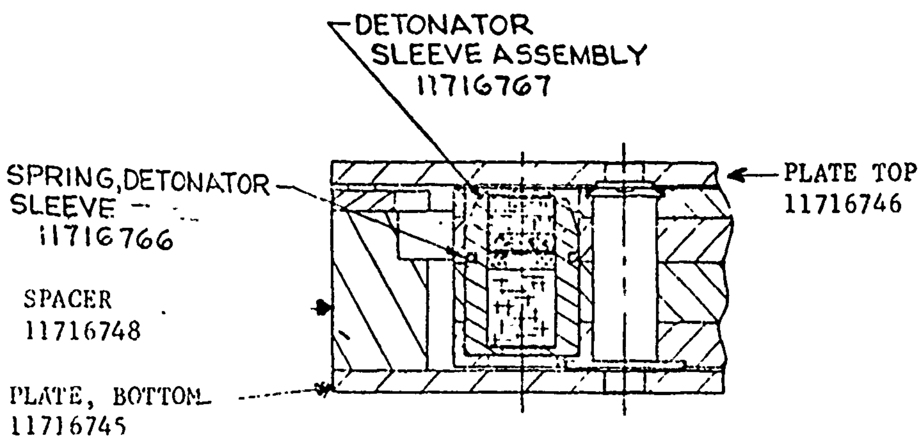


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FIGURE 12 - S & A MODULE PN-11716741 FOR M514SIPI FUZE

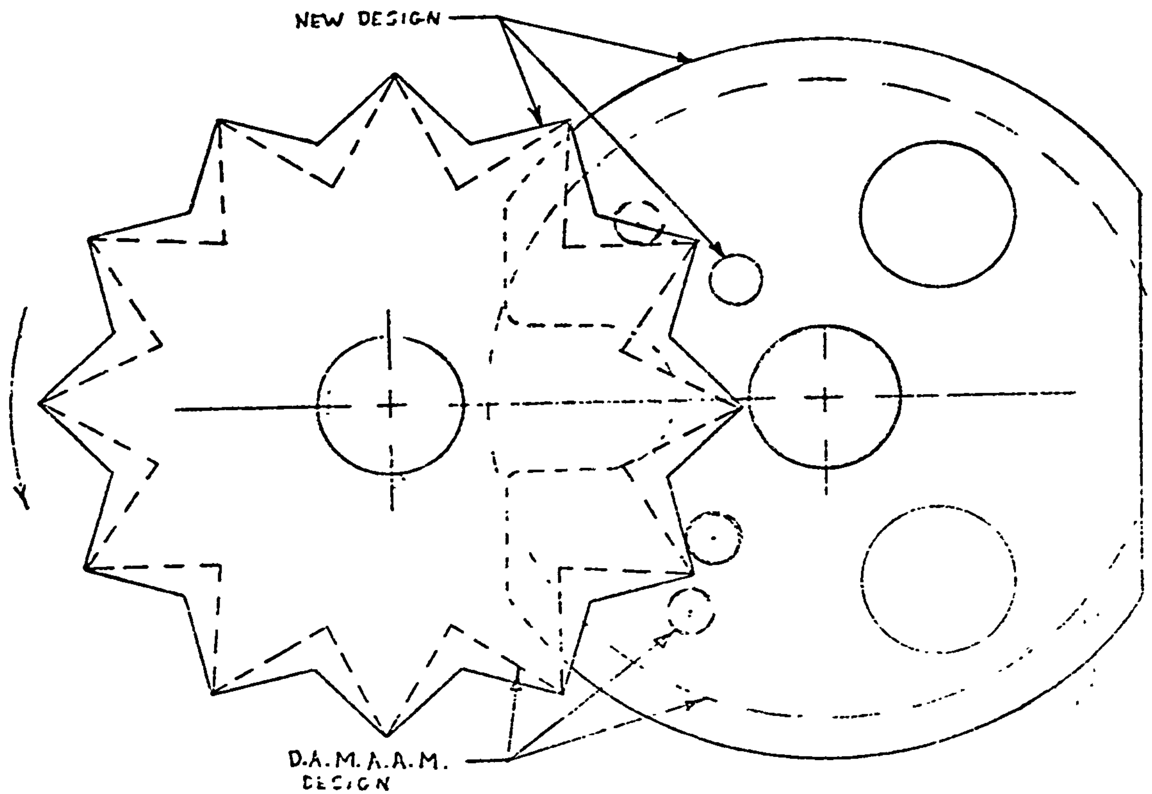

FIGURE 13 - COMPARISON OF D.A.M.A.A.M. AND NEW ESCAPEMENT DESIGNS

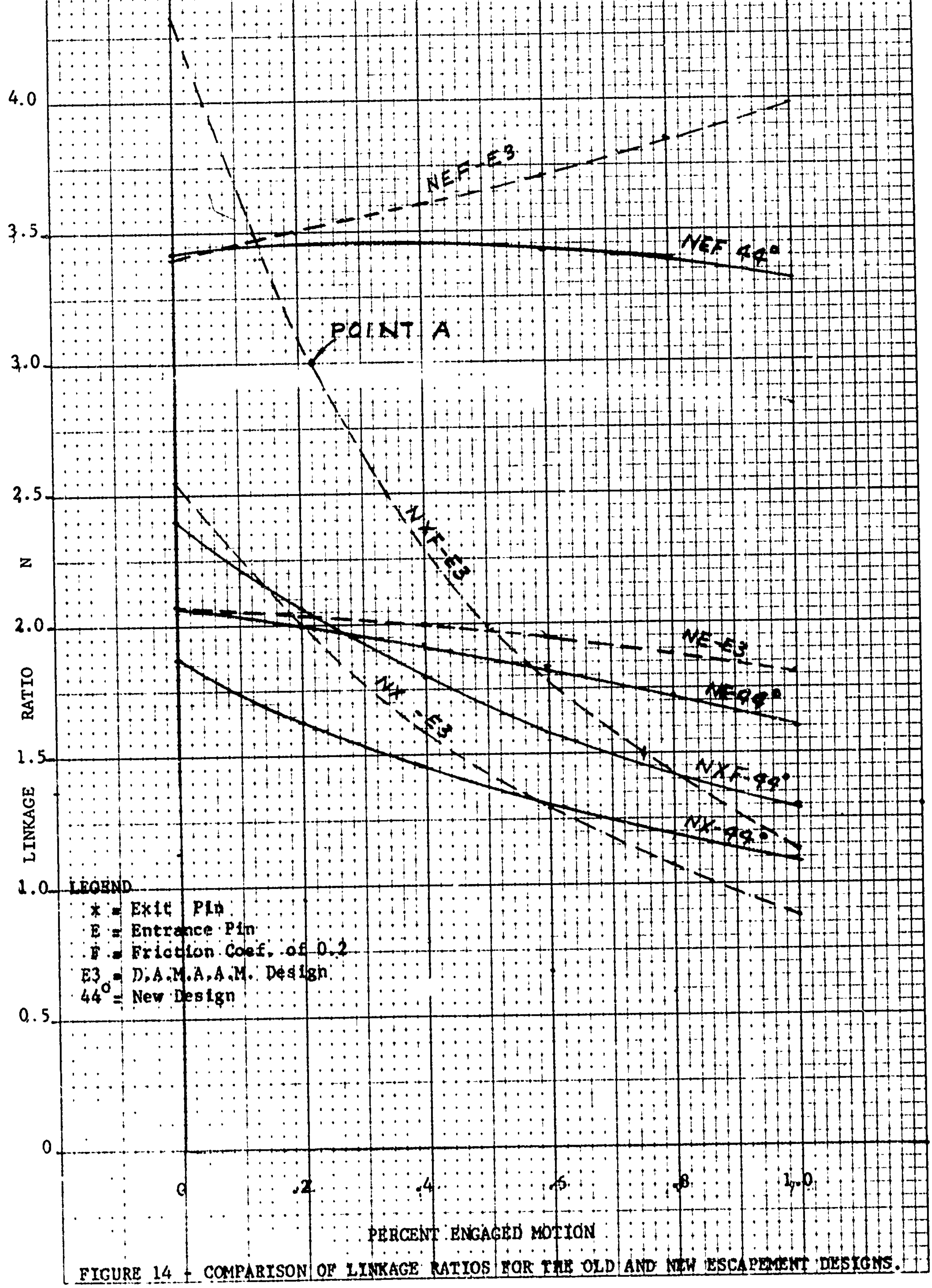

FIGURE 14 - COMPARISON OF LINKAGE RATIOS FOR THE OLD AND NEW ESCAPEMENT DESIGNS.

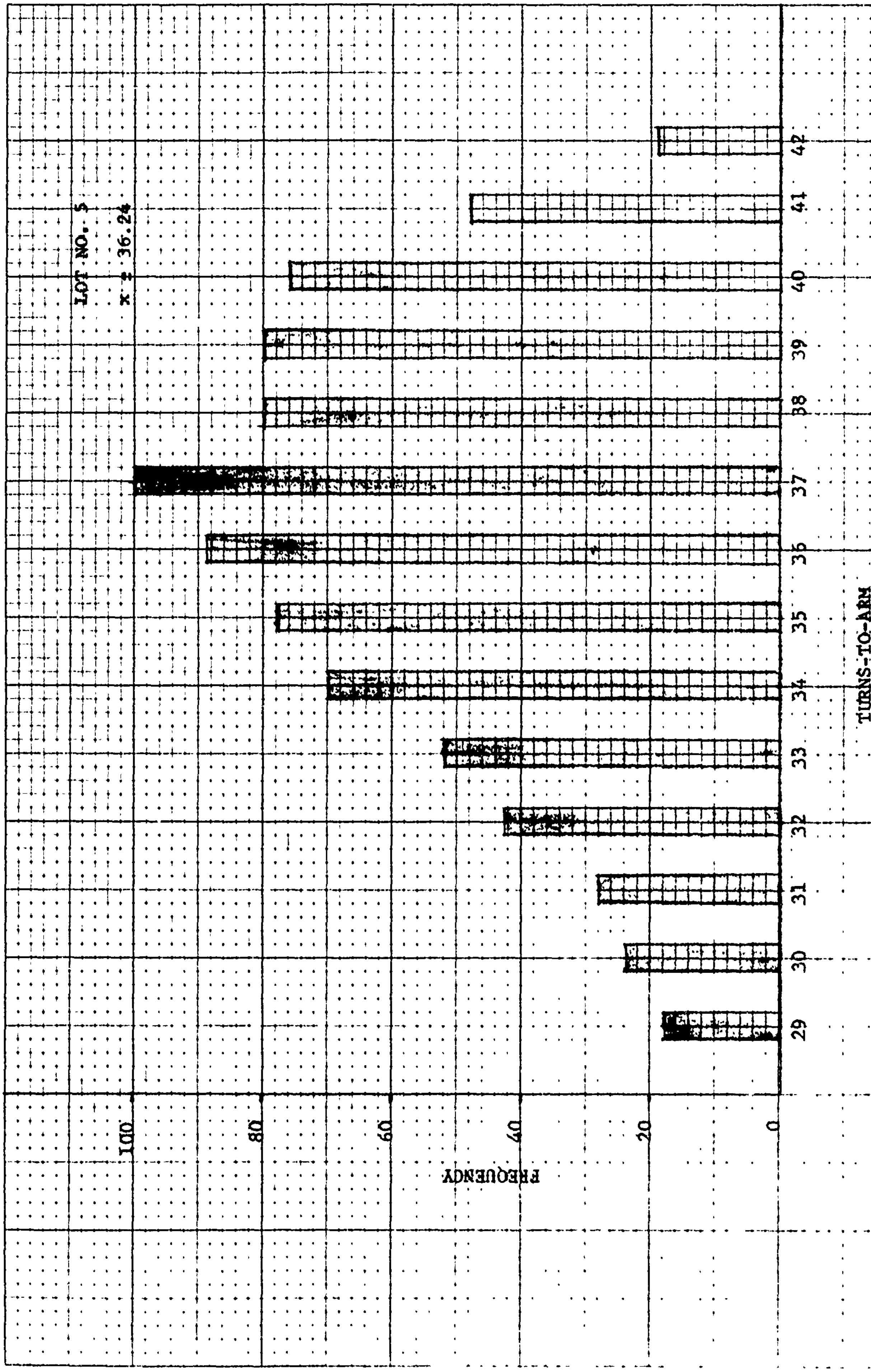

FIGURE 15 - TURNS-TO-ARM DATA FOR LOT NO. 5

TEST	SAFETY	IMPACT SYSTEM BIAS	NON-ARM SPEED	SETBACK LOCK BIAS	TURNS-TO-ARM	DETONATOR FIRING TEST
TRANSPORTATION VIBRATION 50 UNITS	ALL SAFE	44 CHECKED ALL IN SPEC.	35 CHECKED ALL MET SPEC.	44 CHECKED; 35 IN SPEC; 6 OF 9 IN SPEC. ON 2ND TRY OTHER 3 WENT AT 1200 to 1400 G	43 IN SPEC; 1 NO ARM;4 FAST; 2 SLOW; 4 OF 7 IN SPEC ON 2ND RUN; 3 NOT RERUN	NOT DONE
JOLT 24 UNITS	ALL SAFE	NA	NA	NA	NA - BUT: 18 IN SPEC; 2 NO ARM; 4 NO TEST DUE TO TEST FIXTURE	NA
JUMBLE 24 UNITS	ALL SAFE	NA	NA	NA	NA - BUT: 20 IN SPEC; 3 NO ARM 1 ARM SLOW	NA
5 FOOT DROP 50 UNITS	ALL SAFE	41 CHECKED ALL IN SPEC.	29 CHECKED ALL MET SPEC.	41 CHECKED; 29 IN SPEC; 10 OF 12 IN SPEC ON 2nd TRY; OTHER 2 WORKED AT 1270 G.	41 IN SPEC; 1 NO ARM; 8 SLOW; ALL 9 IN SPEC ON 2ND RUN	NOT DONE
40 FOOT DROP 25 UNITS	ALL SAFE	NA	NA	NA	NA	NA
TEMP. COND. $-40^{\circ}F$ 50 UNITS	ALL SAFE	49 CHECKED ALL IN SPEC.	45 CHECKED ALL MET SPEC.	49 CHECKED; 43 IN SPEC; 5 OF 6 IN SPEC ON 2ND TRY; OTHER ONE WENT AT 1430 G.	49 IN SPEC; 1 FAST (27.5); IN SPEC (39.8) ON RETEST	NOT DONE
TEMP. COND. $+160^{\circ}F$ 50 UNITS	ALL SAFE	45 CHECKED ALL IN SPEC.	35 CHECKED ALL MET SPEC.	45 CHECKED; 35 IN SPEC; 5 OF 10 IN SPEC ON 2ND TRY; 1<900 G (BENT SPG) OTHER 4 WENT AT 1200 to 1730 G	44 IN SPEC; 3 FAST; 3 SLOW; 5 IN SPEC ON 2ND RUN; 1 NOT RERUN	NOT DONE
273 TOTAL	273	179	144	$\frac{142 \text{ IN SPEC.}}{179 \text{ ON 1ST TRY}}$	$\frac{215 \text{ IN SPEC.}}{269 \text{ ON 1ST TRY}}$	SEE TEXT

NOTE: CONSULT TEXT FOR DESCRIPTIVE INFORMATION.

FIGURE 16 - SUMMARY OF LOT 5 ENVIRONMENTAL TEST RESULTS